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ABSTRACT

This report describes the strategy adopted by the Fairfax County Public Schools (Virginia) for the implementation of Elementary Science Study (ESS) materials in its schools. A plan was prepared for the implementation: (1) inservice teachers were given training in the use of ESS kits and motivated to use these effectively, and (2) an Instructional Materials Processing Center was established which employed community people on a part-time basis to construct and replenish old ESS kits for use in classrooms. Costs of ESS kits were reduced in most cases, and employment opportunities were provided for the community and students. The number of teachers using the ESS materials in classrooms has increased considerably. The actual use of these materials in classrooms can be measured by the fact that these kits were provided to only those teachers who had shown any interest in the materials and training workshops. (PS)

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PRODUCING ELEMENTARY SCHOOL SCIENCE MATERIALS THROUGH COMMUNITY INDUSTRY

During the past ten years, the Elementary Science Study has been developing "discovery" science units for the elementary grades. However, the problem of providing the large quantities of materials necessary for these science activities at a cost within the reach of a school system has often been a roadblock in the implementation of E.S.S. and other science curricula centered on student investigation.

In addition, there has been the problem of the sheer SIZE of the logistical operation required to keep thousands of elementary school teacher adequately supplied with equipment in good repair and a multitude of expendable items.

During the past two years, the Fairfax County Public School System has demonstrated a way to overcome these obstacles, and in doing so has pioneered in the development of a new kind of school service organization, The Instructional Materials Processing Center. At this Center, community workers are currently manufacturing scientific apparatus and packaging materials.sufficient to supply over two thousand elementary school classroom with a continuous flow of ESS kits.

Originally conceived and piloted in the Greece, New York, school system, the idea for the IMP Center was brought to Fairfax County in 1969 by the late Superintendent of Schools, Lawrence M. Watts. Located in a low-income community, the Center draws upon 30 Neighborhood Youth Corps student workers and 15 adult workers. The creation of the IMP Center thus represents a meshing of two needs: the need of school system for elementary science materials and the need of the local community for a source of employment.

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PRODUCING ELEMENTARY SCHOOL SCIENCE MATERIALS THROUGH COMMUNITY INDUSTRY

A Report On The Elementary Science Study Project

and

Instructional Materials Processing Center

Fairfax County Public Schools

Prepared for
National Science Teacher's Association Convention

by
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Background

Elementary Science Study is one of many curriculum programs developed at Education Development Center (EDC), a non-profit organization in Newton, Massachusetts founded by M.I.T. physicist Jerrold Zacharias. (Other EDC curriculum efforts have included the PSSC High school physics course and the IPS intermediate level physical science course.)

Sponsored by the National Science Foundation, the E.S.S. Project began in 1960 on a small scale to develop materials for teaching science in the elementary grades. Since that time, more than a hundred scientists and educators have been involved in the conception, design, and development of the ESS materials.

The ESS staff at EDC has been primarily concerned with developing materials that motivate children to become actively involved in learning. Unlike many commercially-developed educational programs, the ESS units are not based solely upon educational ideas that an "expert" thinks might work or should work; instead the ESS units were developed from their embryonic stages in classroom settings with the response of children to the materials as the pre-eminant measure of success. Many seemingly good ideas for ESS science activities were discarded in the process of unit development, simply because they did not work out with children in actual classroom settings.

The development of the ESS materials marked a radical departure from the traditional methods of textbook oriented elementary science. In the ESS approach, rather than the teacher's beginning with a discussion of basic concepts of science, materials are put into children's hands from the start, so that each child can investigate, through them, the nature of the world around him. Through this process, children acquire much useful information, not by rote, but through their own active involvment in problem - solving activities. Even more important, this kind of learning experience gives even very young children an opportunity to develop the capacity and the courage to think imaginatively, logically, and critically--in short, to learn to think for themselves.

Perhaps better than any other existing set of materials designed for use by elementary school children, the ESS materials satisfy Bruner's dictum that "if a curriculum is to be effective in the classroom it must contain different ways of activating children, different ways of presenting sequences, different opportunities for some children to 'skip' parts while others work their way through . . . . A curriculum, in short, must contain many tracks leading to the same general goal."[1]

Twenty-four different ESS units are currently being utilized in the Fairfax County ESS program. A brief description of some of the activities involved in each of these units may be found in the Appendix.

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[1]Bruner, J. S. Toward a Theory of Instruction. W. W. Norton & Company, New York City, 1968.

Obstacles to the Implementation of Materials-Centered Elementary Science Courses

Despite the fact that there is a wide consensus of the value of the kinds of learning experiences provided by the ESS materials, school systems, and particularly large school systems, have encountered severe difficulties in the implementation of ESS and similar inquiry-oriented, materials-centered science programs. There have been at least three obstacles to successful implementation.

One obstacle has been the perennial problem of costs. According to Dr. Charles A. Whitmer, Director of the National Science Foundation's Pre-College Education Division, the problem of providing the necessary materials at a cost within the reach of a school system "has been a roadblock in the implementation of elementary science curricula centered on 'hands-on' investigations by students."[1] Even though the ESS developers attempted to utilize whenever possible materials that would be relatively inexpensive to purchase, the cost of commercially-produced ESS kits has been prohibitive for many school systems.

A second obstacle encountered by school systems attempting to implement materials-oriented elementary science courses has been the problem of maintaining the science kits in ready-to-teach condition after their initial purchase. Because large amounts of expendable materials are utilized in many of the ESS science units, some mechanism must be provided to service the kits each term, both to replace the expendable items and to repair, clean and inventory non-expendable items.

A public school system in California is a case in point. After making a large initial investment in commercial materials so that all elementary schools in the system could be equipped with science kits, the system abandoned the program two years later. Kits originally purchased were in complete disorder and no mechanism had been provided for their refurbishment. The bits and pieces which remained of the original kits were sitting on shelves in school storerooms, unusable because critical elements were either broken or missing. Teachers simply did not have the time to inventory and order the missing items, or to repair broken apparatus.

Another example of this kind of problem occurred in a school district in Wisconsin. Arthur G. Suhr, Science Chairman of the Hamilton Joint School District in Wisconsin writes:

"In our first years of using ESS we tried to circulate kits from school to school. It seemed that when two or three classes used the kit it became so badly depleted that further use became impractical.

"Later we supplied each school building with a complete set of kits. We found that kits were again depleted within two or three sessions in class.

"I finally came to the conclusion that someone must be responsible for the delivery, collection, and replenishment of materials in the kit. Apparently teachers cannot keep tract of non-expendables, and few seem to make an attempt to replace expendable materials."[2]

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[1]Personal communication from Dr. Charles A. Whitmer, National Science Foundation.

[2]Personal Communication from Arthur G. Suhr.

The third obstacle to the implementation of inquiry-oriented science programs has been the magnitude of the in-service teacher-training program necessary to ensure that teachers will be able to utilize the materials in the way in which they were conceived. After playing a pioneering effort in the development of some of the early ESS units, and after a highly successful ESS pilot program had been completed, the Montgomery County Public School System in Maryland was forced to abandon their ESS program. School officials report that they were not adequately prepared to provide the amount of in-service training necessary to orient teachers adequately in the use of the new program, and to continue to provide training for the new teachers that entered the system each year. The Montgomery County School System is currently attempting to train a large group of "science specialists", so that another attempt can be made to introduce inquiry science materials at some future date.[1]

The Fairfax County ESS Project

An ESS implementation program was begun in Fairfax County in January, 1970, when the late Superintendent Lawrence M. Watts instituted an ESS Project under the aegis of the Center for Effecting Educational Change (CEEC) located at the Lillian Carey Annex, near Bailey's Crossroads. This ESS Project was designed as an integrated teacher-training and materials-processing effort which would support the introduction of Elementary Science Study units into elementary schools.

From the beginning, two principles guided the development and operation of the ESS Project:

1. ESS kits would be constructed and maintained locally, at a processing center located in an economically depressed area in the County. The intent was to create an organization which could produce ESS kits more cheaply than they could be purchased commercially and, even more important, maintain the kits in a ready-to-teach condition by refurbishing them each semester. In addition, such a "cottage industry" could perform an important economic function in the community in which it was located by providing jobs for students and adults who needed part-time employment.

2. Teacher participation in the program would be voluntary, but each teacher requesting ESS materials would be required to attend an in-service workshop on each unit in order to become eligible to receive a kit. This built-in motivation device for teachers to attend in-service training workshops helped to ensure that the investment in materials was not wasted when the kits reached the classroom: before teaching the unit all teachers had an opportunity to work through the unit and see for themselves how it might be taught successfully. In addition, teachers adopted a more serious attitude toward the utilization of the ESS kits which arrived in their classrooms, because they had to make an effort to qualify to receive them.

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[1]Personal communication with Dr. Elizabeth Wilson, Deputy Superintendent, Montgomery County Public Schools.

The Instructional Materials Processing Center

In March, 1970 an Instructional Materials Processing (IMP) Center was established at the Lillian Carey Annex (a former elementary school), to supply science kits for the teachers who elected to try the ESS units. Originally conceived and piloted in the Greece, New York, school system, the idea for the IMP Center was brought to Fairfax County in 1969 by the late Superintendent of Schools, Lawrence M. Watts. Located in a low-income community, the Center draws upon Neighborhood Youth Corps student workers and part-time adult workers. The creation of the IMP Center thus represented a meshing of two needs: the need of the school system for elementary science materials and the need of the local community for a source of employment. Kits for twelve different ESS units were first produced in limited quantities during the spring of 1970 for use in the staff development summer schools. The same types of kits were then assembled in larger quantities during the summer for use in the schools in the fall, a total of 1650 kits, each kit containing enough materials for a 32-pupil classroom. The production of kits was increased to 2200 in January 1971. Each teacher participating in the ESS program during 1970-71 recieved kits for four or five ESS units during the school year, and had the use of each kit for a period of 3 to 16 weeks, depending upon the unit.

During the spring of 1971, kits for twelve additional ESS units were developed. Production of apparatus and packaging of materials for these kits was completed during the summer of 1971. Currently over four thousand kits of ESS science materials are being delivered to Fairfax County elementary schools.

The ESS kits are assembled in large, double-walled reusable cardboard cartons. Some units are contained in one such carton, while other units require as many as three cartons of materials. During the 1971-72 school year, more than 5000 of these cartons are being shipped from the IMP Center into classrooms, then back to the IMP Center for replenishment. It is the responsibility of the IMP Center to check each science kit that is returned, replenish the expendable items, repair any broken apparatus, and send the kit out again for use at another school. This means that each kit is used twice during the school year. This is a marked savings over a situation in which materials are used two or three months a year and then allowed to collect dust in a storage closet the remainder of the school term.

In setting up the IMP Center, Fairfax County has thus begun to solve a problem that has plagued school systems that have attempted to institute the ESS program in the past: the logistics of maintaining a steady flow of ready-to-teach science materials into classrooms. The staff of the IMP Center works constantly to improve the science kits and encourages teachers using the kits to make comments on possible improvements that might be made. These services--the returning to the Center, checking, replenishing, repair, and modification to fit the needs of teachers--are not available when commercially-packaged kits are purchased.

The Labor Force

The labor required to construct apparatus such as microscopes, circuit boxes and balances and to package the materials that go into the ESS kits has been drawn from a variety of sources. During the spring of 1970, eight women from the Lillian Carey Annex neighborhood were employed on a part-time basis to begin the pre-packaging of materials to be included in the ESS Kits. During the summer of 1970, twenty-seven student workers were employed to continue the kit assembly work and to

construct some of the specialized apparatus required in large quantity. Over 7000 elementary microscopes and 1500 two-pan balances were constructed by these students. The student summer workers included twenty Neighborhood Youth Corps (NYC) workers and two Fairfax Community Action Program (FCAP) workers whose salaries were paid through a grant from the Federal Government.

During the 1970-71 school year, the work force that refurbished the kits included 10 part-time adult workers from the local community as well as high school and intermediate school students working after school. In addition, a pilot program at Lincolnia Elementary School proved that it was feasible to involve special education students in some of the kit assembly tasks, in a sheltered workshop type of setting.

During the summer of 1971, twenty-five student workers and twelve adults from the local community combined their efforts to refurbish kits for the original twelve ESS units, and to prepare the apparatus and materials for twelve new units. In addition to repairing the microscopes and other apparatus contained in the original kits, the student workers manufactured 1600 balance-board fulcrums, 3200 micro-balance stands, 7000 two-pan balances, and 8000 gas analysis racks.

The decision to locate the IMP Center at the Lillian Carey Annex proved to be especially fortuitous with regard to the nature of the labor force, since the surrounding low-income area made feasible the use of Neighborhood Youth Corps and Fairfax Community Action Program workers. For this reason, labor for the initial manufacture of apparatus for the ESS kits has cost the County very little; virtually all fabrication of apparatus has been performed by Neighborhood Youth Corps workers with Federal funding.

Cost of IMP Center Kits vs. Commercial ESS Kits

A considerable cost savings in materials has been effected by manufacturing science apparatus and assembling kits locally for the ESS program. Specific examples are noted in the table on the following page.

In interpreting the table, it is important to note that the cost of teaching a unit utilizing commercially-produced materials includes both the cost of the commercial kit and the cost of the additional materials which a teacher must purchase locally. Many of the commercial ESS kits require the teacher to provide many of her own materials, such as the chemicals for the Mystery Powders unit, potting soil for the Growing Seeds unit, or the assortment of things to count which is central to the Peas and Particles unit. The ESS kits prepared at the IMP Center, on the other hand, are complete with all materials the teacher will need to use.

It is also important to note that the ESS kits sold by commercial suppliers often require the teacher to spend many hours of preparation to acquire and package materials and to construct some of the apparatus required. In Fairfax County, virtually all of this time-consuming preparation of materials is being performed for the teacher by the IMP Center personnel. This facet of the IMP Center operation allows the teacher more "time to teach" and ensures that all of the necessary materials will be available for each science activity.

COMPARATIVE COSTS OF IMP CENTER KITS vs. COMMERCIAL KITS

Kit	Cost of Commercial Kit	Estimated Retail Cost of Additional Items Required To Teach Unit	Total Commercial Cost	Cost of IMP Center Kit	Estimated Cost of Labor Plus Overhead	Total IMP Center Cost	Savings Per Class Kit
Attribute Games & Problems	$144	$6	$150	$69	$13	$82	$68
Batteries & Bulbs	122	51	173	83	32	115	58
Brine Shrimp	30	21	51	13	13	26	25
Colored Solutions	85	3	88	24	21	45	43
Gases and "Airs"	162	6	168	49	34	83	85
Kitchen Physics/Senior Balancing	230	15	245	46	42	88	157
Mystery Powders	15	33	48	18	20	38	10
Primary Learning Activities	113	9	122	66	14	80	42
Rocks and Charts	87	14	101	37	28	65	36
Small Things	171	26	197	40	17	57	140

The Training of Teachers for The ESS Program

In order to teach the ESS materials, many teachers need to develop a new view of teaching, of the learner, and of the entire learning process. In an ESS classroom, the teacher's role is that of a consultant and a catalyst. For this reason, the teacher must begin to see the child as having an extraordinary capacity for learning and become convinced that he learns best from his own activity. In order to adopt this attitude, many teachers must be persuaded to reconceive their role as teachers.

In addition, in order to become successful ESS teachers, elementary school teachers also need to learn the practical details of operating an ESS classroom, such as the details of classroom management, the mechanics of distributing and storing materials, and how the teacher works with a whole class, in small groups, or with individual children.

Because elementary school teachers are typically science-shy, most teachers also need an opportunity to obtain experience with the apparatus and activities involved in a unit themselves, before attempting to work with the unit in a classroom setting. Skimping by not providing such training is poor economy, since the only real outcome of any investment in an instructional program is what actually goes on in the classroom, and the success of any inquiry lesson is dependent upon the teacher's familiarily with the ideas and materials involved.

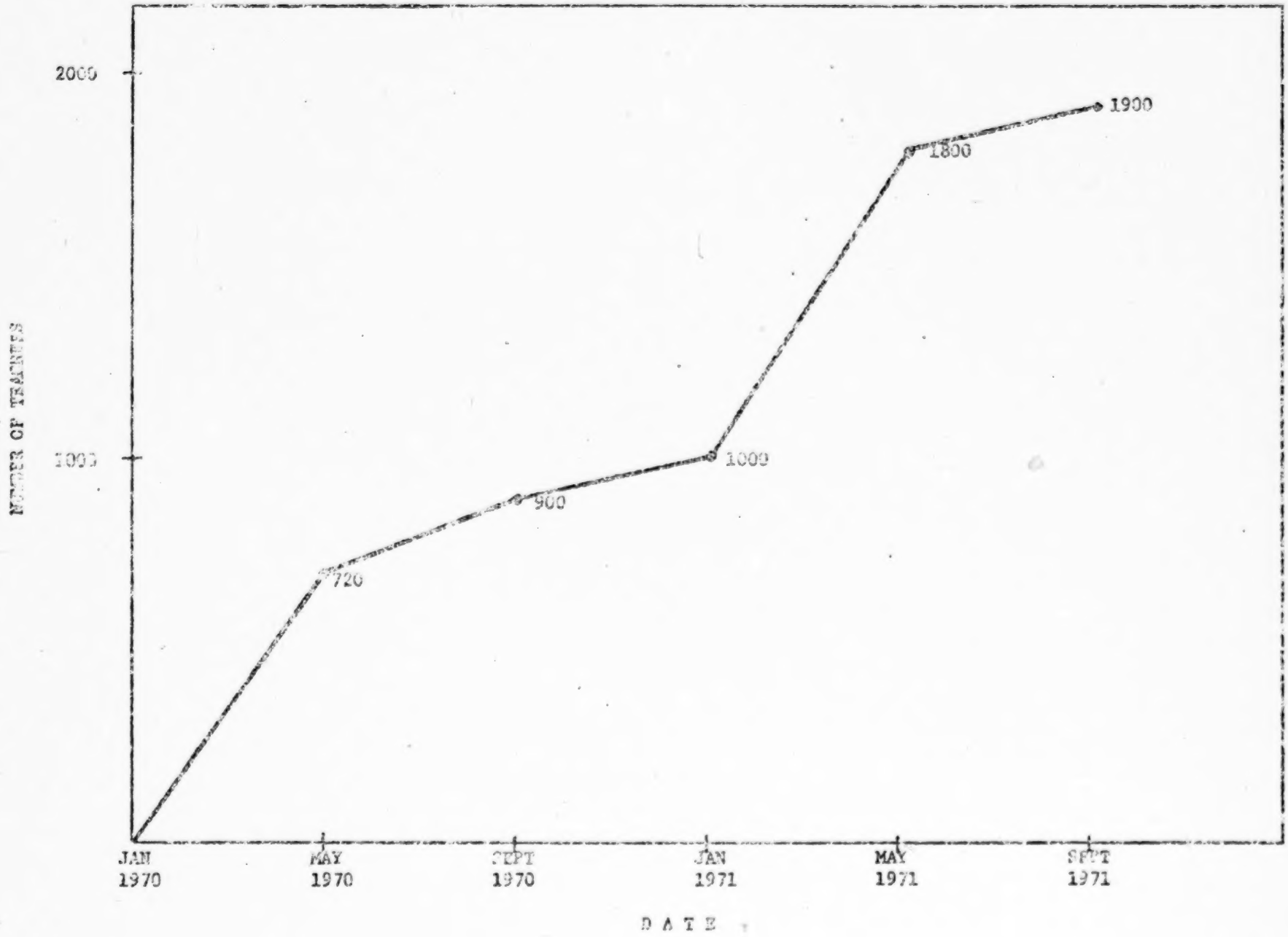
An effort has been made to address the in-service teacher-training program in Fairfax County to the tasks defined above. The graph on the following page summarizes the numbers of teachers participating in the in-service training program since the inception of the ESS Project in 1970.

During the spring of 1970, teachers from one-half of the elementary schools in Fairfax County were introduced to the ESS program at in-service workshops. In-service workshops were conducted by an "innovation team" composed of 24 local educators--elementary supervisors, science supervisors, and principals--who had received extensive training in the use of ESS materials during February and March, and then had an opportunity to work with children in classrooms during March and April. By gaining first-hand experience in teaching one or more ESS units, the innovation team members were able to give their own teaching of teachers considerable credibility and were ready, in May, to conduct workshops in which 720 teachers received training. These teachers were then allowed to decide if they would like to try the ESS materials in their classrooms in the fall. Virtually all of the teachers who attended the in-service workshops decided to try the materials.

During the 1970 summer staff development program, approximately half of the 720 teachers introduced to ESS in May had an opportunity to acquire further in-service training and to gain teaching experience with one or more ESS units. The in-service training program continued during the 1970-71 school year in order to acquaint teachers with additional ESS units. Due to popular demand, the in-service program was expanded to include approximately 1000 teachers in January, 1971.

During April and May of 1971, the in-service training program was expanded to include all of the elementary school teachers in the County who wished to

TEACHER PARTICIPATION IN ESS PROGRAM



participate in the program. Approximately eight hundred teachers volunteered and attended their first ESS workshop during the spring. An additional hundred teachers were added to the program in September, 1971, bringing the total number participating to approximately nineteen hundred teachers.

Teachers participating in the ESS program receive one full day of in-service training in preparation for each semester's ESS units. Thus, during the pre-school work-days in the week before school started in September, 1971, each of the 1900 teachers participating in the program attended an ESS in-service workshop for one day. This meant that during the first week in September, over seventy full-day ESS workshops were held, each workshop taught by a teacher, principal, science helping teacher, or science supervisor who himself had previously obtained personal classroom experience with the ESS unit involved.

Admittedly there has been a large investment of teacher time in ESS in-service training, at least when compared with the amounts of in-service training which elementary school teachers have traditionally received in the past. However, the designers of the ESS units have found that in-service training is the most important element in the ESS program; without adequate training there is a high probability that the ESS materials will either be misused or never used at all.

The critical link is the teacher-child interaction in the classroom. If, through adequate in-service training, we can introduce a spirit of inquiry into ESS classrooms and induce teachers to give children a chance to learn to think independently and creatively, then the investment in time and effort will be well worth its cost.

APPENDIX A

Units of Study

PRIMARY UNITS

PATTERN BLOCKS (Levels 1 & 2)

Pattern Blocks offer children an aesthetic experience and an opportunity to manipulate a large number of wooden shapes and patterns. Utilizing a variety of activities, the unit develops classification skills, spatial relations, and sensori-motor coordination. As the children gain experience in manipulating the 250 flat wooden shapes, additional activities involving pattern construction and recognition, linear and area measurement, angle measure, and symmetry are introduced.

GEO-BLOCKS (Levels 1 & 2)

Geo-Block activities are designed to give children experience with geometric shapes and to develop their understanding of linear, area, and volume relationships. The materials make possible the development of such mathematical concepts as surface area, scaling, grouping, numerical relationships, projections, perspective, and symmetry.

PRIMARY BALANCING (Levels 1 & 2)

Children use familiar materials and simple apparatus to learn about balance and weight. Activities include weighing, comparing, sorting, counting, and balancing a variety of items on several types of balances. After acquiring experience with comparative weight relationships, children are given opportunities to attempt the serial ordering of objects by weight and to work with weight-volume relationships. By using arbitrary units of weight, children develop measurement skills, and acquire an understanding of the need for developing standard systems of weight and measures.

MIRROR CARDS (Levels 1 & 2)

The Mirror Card problems give children an opportunity to acquire some informal geometric experience prior to the development of the concept of symmetry. As they work with the cards, children develop skills in matching and analyzing patterns.

GROWING SEEDS (Levels 1 & 2)

Opportunities are provided for children to study the germination of seeds and plant growth. Children determine the attributes of seeds, examine their internal structure, and learn to make graphs to chart plant growth. An extension of this unit involves a study of plant reproduction through successive generations.

BRINE SHRIMP (Levels 1 & 2)

Children become acquainted with some of the problems confronted by living organisms by raising simple crustaceans, watching their development, and performing simple experiments with them. Through a study of the external structure, digestive system, and life cycle of the brine shrimp, children heighten their power of observation and develop their ability to focus on details.

ATTRIBUTE GAMES AND PROBLEMS (Used at all levels)

Attribute Games and Problems develop thinking skills by providing an opportunity for children to deal with problems involving classification and the relationships between classes. The kit contains four kinds of problem-solving materials: attribute blocks, people pieces, color cubes, and creature cards. This variety of materials allows children to develop the power to generalize by applying a strategy learned in one context to a new situation.

TANGRAMS (Used at all levels)

The Tangram materials provide children with opportunities to work with the basic geometric relationships of area, shape, and proportation. The tangram is a geometric puzzle consisting of seven pieces dissected from a square. The unit includes a set of problem cards that begin with problems involving smaller groups of the seven piece set, in order to help children to develop skill in dealing with basic geometric relationships before they confront more complex problems.

MIDDLE LEVEL UNITS

COLORED SOLUTIONS (Levels 3 & 4)

By utilizing aesthetically pleasing yet simple materials, this unit introduces children to the layering of liquids and the concept of density. The results of the experiments form a foundation of facts from which children may make predictions and draw conclusions about the behavior of liquids. Experience with liquids enables them to develop a scheme for classifying according to density, and to pursue some research problems using the information they have mastered while working with the unit.

ICE CUBES (Levels 3 & 4)

Children experiment with ice cubes to determine factors which influence heat transfer. They investigate the effects of varying surface area, ambient temperature and insulation to influence the rate at which ice melts. In the

course of their work, children collect data from their observations and experiments, and gain considerable experience in measuring time intervals and constructing tables and graphs.

BATTERIES AND BULBS (Levels 3 & 4)

This unit is an introduction to the study of electrical circuits. Students investigate the design of incandescent bulbs and the composition of dry cell batteries. Investigations with simple circuits are followed by more complex circuit analysis involving several bulbs and several dry cells. Students learn to read and draw schematic circuit diagrams, and to solve hidden circuit problems.

ROCKS AND CHARTS (Levels 3 & 4)

In this unit, students develop a classification system to identify twenty-one commonly-occurring minerals. Children are encouraged to look closely at the characteristics of rocks in order to establish ways of comparing and differentiating them. Qualities such as texture, color, hardness, density, crystalline structure, electrical conductivity and chemical reactions are investigated. Chart making assists children further in focusing attention on the minerals themselves, and on the need for standards in identifying and classifying them.

BUTTERFLIES (Levels 3 & 4)

In this unit, children witness the complex life cycle of an insect by raising butterflies in their classroom. By observing the appearance and behavior of the butterflies in great detail, children learn to care for and to protect a living organism. While they watch and care for their butterflies, students ask many questions about them. In time, they find answers to some of their questions, develop an appreciation for the way in which this animal lives, grows, and reproduces, and are introduced to the concept of metamorphosis.

SINK OR FLOAT (Levels 3 & 4)

Preliminary activities in this unit give children an opportunity to gain an intuitive understanding of the concepts of buoyancy and density. Children then carry out investigations which lead them to a more formal understanding of the relationship between the volume of a floating object and the amount of the weight it can support. By working with objects and liquids of different densities, children learn that an object's ability to float in a given liquid involves properties of both the object and the liquid.

MYSTERY POWDERS (Levels 3 & 4)

This unit introduces children to the detailed examination of the chemical and physical properties of some familiar substances. Children identify these chemicals by examining, smelling, feeling, and comparing them with known substances using analytic techniques. At the end of the unit, children pursue several problems in the qualitative analysis of "unknowns", using chemical tests and indicators. The unit immerses children in investigatory science, in which the student obtains answers to his questions directly from experimentation.

UPPER LEVEL UNITS

SMALL THINGS (Levels 5 & 6)

Small Things introduces children to the microscopic world. Children learn to operate the instruments needed to make it accessible, and become familiar with the appearance and structure of minute living and non-living things. Children first explore magnification with water drops and hand lenses. They then become acquainted with a microscope, and gradually improve their slide-preparation techniques while investigating crystal growth, plant cell structure, micro-animals, and cell division and growth.

BEHAVIOR OF MEALWORMS (Levels 5 & 6)

Behavior of Mealworms stimulates children to ask questions about the observable behavior of an unfamiliar animal and then directs them to find the answers for themselves. As children observe and experiment, they learn about the process of scientific inquiry while they gather information about the sensory perception of the mealworm. The primary objective of the unit is to give children an opportunity to design experiments which test their theories of animal behavior.

PENDULUMS (Levels 5 & 6)

The study of pendulums offers children the opportunity to observe, investigate, and reflect upon the many physical phenomena associated with swinging objects. A variety of pendulum bobs, differing in weight, size, and shape, lead children to investigate the effects on the pendulum's motion of the length of the string and the weight and shape of the bob. A number of questions concerning energy transfer are investigated when the children couple two pendulums together, to observe the effect one swinging object has on another. Students sharpen their ability to make predictions by solving a variety of problems concerning the amplitude, frequency, and complex motions of a variety of oscillating pendulum systems.

PEAS AND PARTICLES (Levels 5 & 6)

This unit gives children an opportunity to develop a number of strategies in dealing with large numbers, sizes, distances, and the making of accurate estimations. The activities are designed to give children experience in comprehending and dealing with the large numbers and orders of magnitude that are often found in newspapers, budgets, surveys, and other areas of everyday life.

GASES AND "AIRS" (Levels 5 & 6)

This unit is composed of closely-linked laboratory experiments investigating the nature of air and the changes it undergoes when interacting with materials and organisms in the environment. Students perform experiments involving the expansion of gases, and gain an intuitive understanding of the gas laws. Using careful analytic techniques, students analyze a variety of gases for oxygen content and gain experience with an essential tool of experimental science - isolating and controlling variables.

KITCHEN PHYSICS (Levels 5 & 6)

This unit is a study of the characteristic properties of a number of common liquids. Children investigate such properties as surface tension, adhesion, and viscosity. A series of experiments are performed to test the effect of surface tension, and cohesive forces on the absorption and evaporation of different liquids. Children construct and calibrate a balance capable of weighing objects to one-tenth of a gram, in order to investigate problems involving the concept of density. Then the balance is converted into a tensiometer which permits a quantitative analysis of the surface tension of a variety of liquids.